to tell us whether it is in use in the Orkneys and the Hebrides, or elsewhere, where the people still spin their own wool.

COSMOPOLITAN

MEASURING HEIGHTS [1]

THE system of barometric hypsometry described in this treatise—first communicated in 1877 to the Philosophical Society of Washington—was suggested by the needs of the geographical surveys conducted by the Government of the United States in the mountainous region lying between the Great Plains and the Pacific Ocean. The system proposes a new method of observation and computation. It is not of universal application, but the range of work to which it is adapted is large and deserving the attention of the geographer.

The *method of observation* is as follows:—Two base stations are established—one high, the other low. Their difference in altitude is made as great, and their horizontal distance as small, as practicable. Each station is furnished with a barometer only, and observations are made at frequent intervals through each day. At each new station a barometer is observed, and no other instrument. The difference in altitude of the two base stations is determined by spirit level, and forms a vertical base by which all other intermediate altitudes are *computed as follows*:—The readings, being corrected for index error and temperature of instrument, are collected in groups of three, each observation at a new station being accompanied with the simultaneous observations at the two base stations. The resulting difference of heights of the lower and the new station is then computed by the following formula, in which if L, U, N represent the height of the lower, upper, and new stations respectively, and l, u, n the simultaneous corrected barometric readings at the same stations, and also let $B = U - L$, $A = N - L$, and $B - A = U - N$; then it is found approximately that—

$$A = B\frac{\log l - \log n}{\log l - \log u} + \frac{A(B-A)}{D}.$$

where $D = 490{,}000$, if A and B are reckoned in *feet*; or 149,349 if in *metres*. This formula consists of two terms—the first, or *logarithmic term*, is the principal one; the second, or *thermic term* (so called), is always very small in comparison with the first—so that it suffices to substitute for A in the second term the value of the first. The following example of computation further illustrates the formula:—

In August 1872 the simultaneous mean pressures at Sacramento, Colfax, and at Summit were 29·879, 27·475, and 23·336 inches respectively, and the altitude of Summit above Sacramento is 6989 feet. Required the altitude of Colfax above Sacramento. In this case:—

$$l = 29\cdot879 \qquad \log l = 1\cdot47537$$
$$n = 27\cdot475 \qquad \log n = 1\cdot43894$$
$$u = 23\cdot336 \qquad \log u = 1\cdot36803$$
$$\log l - \log n = 0\cdot03643$$
$$\log l - \log u = 0\cdot10734$$

$$\log(0\cdot03643) = -\,2\cdot56146$$
$$\log(0\cdot10734) = -\,1\cdot03076$$

$$\text{Difference} = -\,1\cdot53076$$
$$\log B = 3\cdot84441 \quad 6989 = B$$

$$\text{sum} = \log(\text{first term}) = 3\cdot37511 \ldots 2372\cdot0 = \text{first term} = A \text{ nearly}$$
$$\log(B-A) = 3\cdot6644 \ldots 4617 = (B-A) \text{ (approximately)}$$
$$\text{colog}(490000) = -\,6\cdot3098 \ldots$$

$$\text{Sum} = 1\cdot3493 = \log 22\cdot4 \ldots \text{the second term}$$

Required difference of altitude = 2394·4 feet.

[1] "A New Method of Measuring Heights by Means of the Barometer." By G. K. Gilbert. Extract from the Annual Report of the Director of the U.S. Geological Survey, 1880-81. (Washington: Government Printing Office, 1882.)

The author, considering the direct calculation of the second term inconvenient, has calculated a table of double-entry showing the value of this term as a correction of the first term for every 100 feet of B and of the approximate value of A, which is appended. A graphic table is also appended (plate lxii.) for computation of this *thermic* correction. However, as the table of logarithms must be to hand, the direct calculation does not seem to present any particular inconvenience.

By thus abandoning the thermometer and psychrometer, and employing the barometer alone, the author reverts to elementary principles upon which all barometric measurements depend, and presents in his first chapter a review of the purposes and conditions of barometric hypsometry in general, and although not presenting anything new, is yet very interesting. The principle which underlies the measurement of heights by the barometer is exceedingly simple, but its application is fraught with difficulty. The law of the relation of altitude to atmospheric pressure is consequent on the law of the compressibility of gases, and is simply a certain multiple of the logarithm of the air-pressure. But there are numerous modifying conditions which must be considered in the application of this law. After describing the construction of barometers, of which the mercurial is both the oldest and the most accurate, the author passes to the consideration of the modifying conditions of the temperature and humidity of the atmosphere which are ever varying, so that the static order of densities is broken, currents are set in motion, and the circulation and the inequalities of temperature conspire to produce inequalities of moisture. Every element of equilibrium is thus set aside, and the air is rendered heterogeneous in composition, temperature, and density. Moreover, the disturbing factors are so multifarious and complex that there is infinite variety of combination and infinite variety of result. Approximate solutions of the problem are therefore only expected; and the author, after describing the disturbing factors—gradients, temperature, humidity—and the various devices for the elimination of the errors due thereto, and other general devices for diminishing hypsometric errors and the relative importance of different sources of error, arrives at the conclusion that the difficulties which inhere in the use of the barometer for the measurement of heights are so numerous and so baffling that there is no reason to hope they will ever be fully overcome. The best that can be done is to mitigate them, keeping in mind that the barometric method must not be so elaborate that its cost will approach that of the use of the spirit level. The problem, therefore, which occupies the attention of those who have occasion to use the barometer in extended surveys is how to secure the best result from a single observation at a new station combined with a series of observations at one or more base stations.

The author next proceeds in the second chapter to develop his *new method*, as explained above, and determines a mean value of the *thermic constant*, *D*. In Chapter III., on "Comparative Tests," various tables are given of the comparative results obtained by means of the new method and the ordinary and other empirical methods in use. This comparison shows the advantage of the new method in a reduction of one-half the error of the ordinary method, and one-fourth that of the empiric method. Nevertheless there is a considerable range of special cases in which the ordinary method can never be superseded.

Having shown that the new method is theoretically plausible and practically successful, the author considers in the fourth chapter the nature of possible improvements. This chapter, and the following fifth chapter on the limits of utility, and the sixth on the work of others, are more specially addressed to the students of hypsometry. This interesting work closes with a short chapter, the seventh,

on the use of the table of the values of the *thermic term* —before-mentioned—and a supplementary note on devices to eliminate the influence of wind-pressure.

It may be stated that of the seven plates referred to as illustrating this work, six are wanting in the copy now under notice.

ON A METHOD OF ESTIMATING THE STEADINESS OF ELONGATED SHOT WHEN FIRED FROM LARGE GUNS

IN October last it was stated in the newspapers that "at the request of Lord Alcester," and in the presence of the Lords of the Admiralty, "comparative trials of a Krupp gun and a 6-inch breechloader took place *greatly to the advantage of the former.*" . . . "The projectile used in the English weapon was 100 lb. with a 34 lb. charge, and that in the Krupp gun 64 lb. with a 14 lb. charge, *the results from the latter being far in advance of the former.*" If this statement be exact, the matter calls for the most careful consideration. In such a case the superiority of the Krupp gun must have arisen either from the higher initial velocity, or from the greater steadiness imparted to the shot by the Krupp gun, or probably from both these causes combined. The comparative merits of these or any other guns could be very readily settled by well-known methods of experimenting, at the expense of little more than the cost of 5 to 10 rounds of ammunition for each gun. There is no necessity for a repetition of the Armstrong and Whitworth competition, said to have cost some 30,000*l.*

Numerous experiments were made in this country in 1867-68 with guns of 3, 5, 7, and 9 inches calibre, to determine the resistance of the air to the motion of both round and elongated projectiles. Coefficients of resistance were then determined for all velocities between 900 f.s. and 1700 f.s. Additional experiments were made in 1878-79 with elongated projectiles alone, which gave the coefficient of resistance K corresponding to all velocities between 430 f.s. and 2250 f.s. But after this report had been printed, which contained general tables for both *time* and *space* within the above-named limits of velocity, it was decided to have additional experiments made with both lower and higher velocities. The final report of these experiments was published in 1880, which contained general tables for *space* and *time* for velocities between 100 f.s. and 2900 f.s. The values of K_v corresponding to the velocity v, as given in this report, will be hereafter referred to as the "tabular" values of K_v. The weight of a cubic foot of air was taken to be 534·22 grains.

In testing any new gun I would proceed, as in the above-named experiments, to measure the times occupied by the shot in passing over a succession of equal distances. These observations would readily give the velocity v of the shot at any point of its path, and also the corresponding coefficient of resistance K_v. Then according as the mean value of K_v derived from 5 to 10 rounds, was found to be *greater* or *less* than the tabular value of K_v, it would be evident that the gun on its trial gave a *less* or *greater* degree of steadiness than the average of the guns used in the experiments of 1867, &c.

Let us examine the relative value of these four guns in rounds where the middle velocity was about 1280 f.s.

Rounds 6-12, 124 and 126 were fired from the 3-inch gun, with projectiles of 9 lb., giving for K_{1280} respectively the values 136·5, 110·7, —, 114·5, 118·2, 121·0, 119·2, 111·7, and 111·2; the mean of which, 117·9, is 8·9 *higher* than 109·0, the tabular value of K_{1280}. Consequently this gun falls *below* the average in steadiness very decidedly.

Rounds 164-168 were fired from a 5-inch gun with projectiles of 47·68 lb., giving for K_{1280} respectively the values 110·3, 98·9, 91·0, 101·5, and 97·9; the mean of which, 99·9, is therefore 9·1 *below* 109·0, the tabular value of K_{1280}. Consequently these solid 5-inch shot had a very *high* degree of steadiness.

Rounds 148-153 were fired from the same 5-inch gun, but with hollow projectiles of 23·84 lb., giving for K_{1280} respectively the values 105·1, 113·4, 101·5, 105·4, 107·7, and 102·0; the mean of which, 105·9, is 3·1 *below* 109·0, the tabular value of K_{1280}. The steadiness of these shot was *above* the average, but inferior to that of the solid 5-inch shot.

Rounds 97-101 were fired from a 7-inch gun, with projectiles of 123·125 lb., giving for K_{1300} respectively the values 109·8, 118·7, 108·6, 117·6, and 117·5; the mean of which, 114·4, is 5·8 *greater* than 108·6, the tabular value of K_{1300}. The 7-inch projectiles were therefore *deficient* in steadiness.

Rounds 218-221 and 228 were fired from a 9-inch gun with projectiles of 250 lb. giving for K_{1280} respectively the values 110·4, 104·8, 126·0, 118·9, and 131·2; the mean of which, 118·2, is 9·2 *above* the tabulated value 109·0 of K_{1280}. The 9-inch shot were therefore very *unsteady.*

We thus arrive at the character of each of the experimental guns from the error in K_v. In the 3-inch gun the error was $+ 8·9$; in the 5-inch gun (solid shot), $- 9·1$; in the 5-inch gun (hollow shot), $- 3·1$; in the 7-inch gun, $+ 5·8$; and in the 9 inch gun, $+ 9·2$.

Some experiments were made with projectiles provided with various forms of heads in 1866. Although the programme was never fully carried out, the rounds fired with hollow ogival-headed shot of one and two diameters were tolerably numerous. The two forms of shot were fired alternately, and gave the following values of K_{1400}.

Round	One diameter	Error	Round	Two diameters	Error
14	108·6	+0·1	15	108·0	+4·6
16	113·1	+4·6	17	—	—
18	109·6	+1·1	19	—	—
20	108·0	−0·5	21	103·5	+0·1
22	105·3	−3·2	23	104·6	+1·2
24	110·1	+1·6	25	99·1	−4·3
26	108·1	−0·4	27	100·8	−2·6
28	108·4	−0·1	29	103·0	−0·4
30	109·6	+1·1	31	104·0	+0·6
32	104·4	−4·1	33	104·2	+0·8
	10)1085·2	16·8		8)827·2	8)14·6
Means ...	108·5	1·7	Means ...	103·4	1·8

The tabular value of K_{1400} is 104·7, which was derived from experiments made with ogival-headed shot struck with a radius of one diameter and a half. The unit of K in the above cases corresponds to about the 1/50,000 of a second.

M. Krupp has recently circulated some tables which are based on coefficients, a little less than the tabular numbers above referred to, and about such as would have been obtained if I had used those coefficients only which were given by the most steady moving projectiles. Since 1868 there have been great improvements made in the manufacture of slow-burning powder, &c., which may have tended to give increased steadiness to the shot, and thus to reduce the resistance of the air slightly. Still I do not think it desirable at present to reduce my coefficients sensibly, because in all my experiments the velocities have been determined during the motion of the shot just after it had left the gun. But when the range of the shot is considerable, the direction of the axis of the shot must become inclined to the direction of the motion of the shot, and this must increase the resistance of the air. If it was thought desirable to reduce the coefficients of resistance throughout any range in a particular case by $\frac{1}{20}$th or $\frac{1}{10}$th, &c., this could easily be effected by multiplying $d^2 \div \omega$ by $(1 - \frac{1}{20})$, $(1 - \frac{1}{10})$, &c. For heavy shot the range should be extended much beyond 500 yards.

The pamphlet alluded to above is entitled "Table de Krupp pour le calcul des vitesses restantes horizontales et des durées de trajet des projectiles oblongs. Essen,